ELECTROMAGNETIC SWITCH DEVICE

Technical Field

The present invention relates to an electromagnetic switch device for star-delta connections, and more particularly to an electromagnetic switch device designed to be used for a star-delta starter adapted to start up a three-phase electric motor in order to allow the motor to be driven at its full speed within a short period of time.

Background Art

As well known, star (Y)-delta (Δ) starters, which are used to start up an electric motor, serve to establish a star connection for the electric motor upon the start-up of the electric motor, thereby reducing starting current and starting torque required in the start-up of the electric motor to a 1/3 level, while switching the connection for the electric motor into a delta connection after completion of the start-up of the electric motor so that the electric motor is driven in the delta connection state. Such star-delta starters are widely used in a variety of industrial fields in order to protect electric motors and peripheral devices thereof from overload.

Star-delta starters are classified into a contact type using an electromagnetic switch device adapted to switch electric contacts by use of electromagnets, and a non-contact type using a semiconductor switch device. The type using an electromagnetic switch device is more widely used.

FIGS. 1a, 1b and 2 illustrate a conventional electromagnetic switch device and a star-delta starter using the electromagnetic switch device, respectively. FIG. 1a is a perspective view illustrating the

electromagnetic switch device, and FIG. 1b is a cross-sectional view taken along the line a - a of FIG. 1a. FIG. 2 is an equivalent circuit diagram illustrating the star-delta starter.

As shown in FIGS. 1a and 1b, the conventional electromagnetic switch device, which is denoted by the reference character C, includes a body 1, and a cover 2 detachably attached to an upper surface 1a of the body 1. Three pairs of terminals 3 are disposed on the upper surface 1a of the body 1 in such a fashion that the terminals of each terminal pair are arranged at opposite sides of the body 1, respectively, while being insulated from one another. Electric power lines not shown are connected to the terminals 3, respectively. Isolating plates 4 are arranged at opposite sides of the cover 2 to isolate adjacent ones of the terminals 3.

Three pairs of fixed contacts 5 are also arranged on the upper surface 1a of the body 1. Each fixed contact 5 is arranged at an end of an associated one of the terminals 3 extending toward a central portion of the body 1. The fixed contacts 5 are insulated from one another. A vertical moving member 6 is arranged at the central portion of the body 1 in such a fashion that it is upwardly and downwardly movable. Three pairs of moving contacts 7 insulated from one another are mounted to the vertical moving member 6 at opposite sides of the vertical moving member 6 in such a fashion that each of the moving contacts 7 selectively comes into contact with an associated one of the fixed contacts 5 so that it is short-circuited or opened with respect to the associated fixed contact 5. A compression coil spring 8 is arranged around the vertical moving member 6 between the upper surface 1a of the body 1 and the moving contacts 7 in such a fashion that it always urges the vertical moving member 6 upwardly.

A fixed core 9 is arranged at a lower portion of the body 1. A coil 10 is wound around the fixed core 9 in order to form an electromagnet. Above the fixed core 9, a moving core 11 is arranged in such a fashion that it moves vertically along with the vertical moving member 6 in accordance with a magnetization of the electromagnet.

The conventional star-delta starter using electromagnetic switch devices having the above mentioned configuration includes an electromagnetic switch device C1 for a main circuit, an electromagnetic switch device C2 for a star circuit, and an electromagnetic switch device C3 for a delta connection, which are connected together as shown in the equivalent circuit diagram of FIG. 2 and activated by a timer (not shown) separately installed.

When current flows through the coil 10 of the electromagnetic switch device C2 for the star circuit upon starting a three-phase electric motor M, the electromagnet formed by the fixed core 9 and coil 10 is magnetized by virtue of the current.

Accordingly, the electromagnet generates a magnetic force greater than the resilience of the spring 8, so that the vertical moving member 6 and moving core 11 are downwardly moved. As a result, the moving contacts 7, which also move downwardly, come into contact with the fixed contacts 5, respectively.

When the electromagnetic switch device C1 for the main circuit is activated in accordance with the same procedure as mentioned above, a star connection is established for the three-phase electric motor M, so that the three-phase electric motor M is started up using starting current and starting torque reduced to a 1/3 level. At the same time, the timer (not shown) separately installed begins to operate in order to count

the drive time of the three-phase electric motor M.

After a predetermined period of time elapses, the current flowing through the coil 10 of the electromagnetic switch device C2 for the star connection is cut off by an operation of the timer. At the same time, current flows through the coil 10 of the electromagnetic switch device C3 for the delta connection.

In this state, the magnetic force of the electromagnet formed by the fixed core 9 and coil 10 of the electromagnetic switch device C2 for the star connection disappears. As a result, the vertical moving member 6 is upwardly moved along with the moving core 11 and moving contacts 7 by virtue of the resilience of the spring 8, thereby causing the moving contacts 7 to be separated from the fixed contacts 5.

Meanwhile, the electromagnet formed by the fixed core 9 and coil 10 of the electromagnetic switch device C3 for the delta connection is magnetized by virtue of the current flowing through the coil 10. As a result, the moving contacts 7 are downwardly moved, so that they come into contact with the fixed contacts 5, respectively.

Accordingly, the electromagnetic switch device C3 for the delta connection is short-circuited to electric power lines at its one-side terminals 3. As a result, the three-phase electric motor M is switched to the star connection state to a delta connection state, so that it is driven at a full speed.

In the star-delta starter having the above mentioned configuration, each of its electromagnetic switch devices is used only for a single purpose, that is, a star connection or a delta connection. For this reason, the conventional star-delta starter cannot implement a desired system unless at least three

electromagnetic switch devices including the electromagnetic switch C1 for the main circuit, the electromagnetic switch C2 for the star connection, and the electromagnetic switch C3 for the delta connection, as shown in FIGS. 3a and 3b.

FIG. 3a is a view illustrating a practical connection of a three-phase motor provided with a convention electromagnetic switch device. FIG. 3b is an equivalent circuit diagram of the conventional electromagnetic switch device shown in FIG. 3a.

In the case of a two-contact type electromagnetic switch device, there is always a possibility of danger because a main power source is directly connected to a motor. For this reason, 3-contact type electromagnetic switch devices are mainly used in motors of a large capacity. For instance, electromagnetic switch devices having a configuration described in detail in conjunction with FIGS. 1 and 2 have been used in diverse fields. Practically, three electromagnetic switch devices C, that is, the electromagnetic switch device C1 for the main circuit, the electromagnetic switch device C2 for the star connection, and the electromagnetic switch device C3 for the delta connection, are used in a state assembled together under the condition in which the timer T is additionally installed, as shown in FIGS. 3a and 3b. For this reason, there is a high rate of erroneous line connections. Furthermore, there are disadvantages such as high manufacturing and installing costs and a large occupation space.

The conventional star-delta starter also involves a complex wiring for the connection between the electric motor M and each electromagnetic switch device C. Such a complex wiring may result in a possibility of erroneous connections. As a result, the motor M may be frequently damaged, thereby resulting in a possibility of a severe

accident.

Disclosure of the Invention

Therefore, an object of the invention is to solve the above mentioned problems involved in the prior art, and to provide an electromagnetic switch device for star-delta connections which includes two electromagnets arranged in its body and two switching units operating in accordance with respective magnetization states of the electromagnets in order to selectively establish a star connection or a delta connection for a three-phase electric motor, so that it can reduce installation costs and an occupation space when it is applied to a star-delta starter while using no unnecessary wiring, thereby reducing erroneous connections and erroneous operations.

In accordance with the present invention, this object is accomplished by providing An electromagnetic switch device for star-delta connections comprising: a body; first through third power terminals arranged at one side portion of the body on an upper surface of the body and respectively connected to three-phase power lines; first through third main terminals arranged at an intermediate portion of the body on the upper surface of the body and respectively connected to one-side terminals of a three-phase electric motor; first through third star-delta terminals arranged at the other side portion of the body on the upper surface of the body and connected to the other-side terminals of the three-phase electric motor, respectively; a star connection plate set on the upper surface of the body and adapted to connect the first through third star-delta terminals to a star circuit; first through third contacts set beneath the star connection plate and adapted to connect the first through third star-delta terminals to a delta circuit; a timer assembled to the body at a bottom of

the body while being integral with the body, the timer serving to control a start-up time for the three-phase motor ; an electromagnet for a main circuit and an electromagnet for star-delta connections each including a fixed core and a coil assembled in the interior of the body, each of the electromagnets being selectively magnetized in accordance with a cooperation of the fixed core and coil thereof; a main circuit switching unit for selectively connecting the first through third power terminals with the first through third main terminals, respectively, in accordance with the magnetization of the main circuit-end electromagnet; and a star-delta connection switching unit for connecting the star connection plate to the first through third star-delta terminals in accordance with the magnetization of the main circuit-end electromagnet under a condition in which the first through third power terminals are connected with the first through third main terminals, thereby allowing the three-phase motor to be start up in a star connection state, the star-delta connection switching unit also serving to connect the first through third delta connection contacts to the first through third star-delta terminals when the star-delta connection-end electromagnet is magnetized in accordance with an operation of the timer after the start-up of the three-phase motor, thereby causing the three-phase motor to be driven in a delta connection state; whereby the electromagnetic switch device has a configuration capable of enabling a selective connection of the three-phase electric motor to the star circuit or the delta circuit while simplifying a wiring for the connection.

Brief Description of the Drawings

The above objects, and other features and advantages of the present invention will become more

apparent after a reading of the following detailed description when taken in conjunction with the drawings, in which:

FIGS. 1a, 1b and 2 illustrate a conventional electromagnetic switch device and a star-delta starter using the electromagnetic switch device, respectively, wherein FIG. 1a is a perspective view illustrating the electromagnetic switch device, FIG. 1b is a cross-sectional view taken along the line a - a of FIG. 1a, and FIG. 2 is an equivalent circuit diagram illustrating the star-delta starter; and

FIG. 3a is a view illustrating a practical connection of a three-phase motor provided with a convention electromagnetic switch device;

FIG. 3b is an equivalent circuit diagram of the conventional electromagnetic switch device shown in FIG. 3a;

FIG. 4 is a perspective view illustrating an electromagnetic switch device according to the present invention;

FIG. 5 is an equivalent circuit diagram of a star-delta starter using the electromagnetic switch device according to the present invention;

FIG. 6a is a cross-sectional view taken along the line A - A of FIG. 4;

FIG. 6b is a cross-sectional view taken along the line B - B of FIG. 4;

FIG. 6c is a cross-sectional view taken along the line C - C of FIG. 4;

FIG. 7a is a perspective view illustrating a main circuit switching unit applied to the electromagnetic switch device of the present invention;

FIG. 7b is a perspective view illustrating a star-delta connection switching unit applied to the electromagnetic switch device according to the present

invention;

FIG. 8a is a view illustrating the practical connection state of a three-phase motor to which the electromagnetic switch device of the present invention is applied; and

FIG. 8b is an equivalent circuit diagram illustrating the electromagnetic switch device of the present invention shown in FIG. 8a.

Best Mode for Carrying Out the Invention

FIG. 4 is a perspective view illustrating an electromagnetic switch device according to the present invention. FIG. 5 is an equivalent circuit diagram of a star-delta starter using the electromagnetic switch device according to the present invention.

As shown in FIGS. 4 and 5, the electromagnetic switch device of the present invention, which is denoted by the reference character C, is designed to achieve a stable three-contact type connection, in order to eliminate problems resulting from an instable two-contact type connection implemented in conventional cases. The electromagnetic switch device according to the present invention has a configuration in which a timer 170 is contained in a body 110, along with a system for switching on and off a main power source, and switching systems for a star connection and a delta connection, as shown in FIGS. 4 and 5.

FIG. 6a is a cross-sectional view taken along the line A - A of FIG. 4. FIG. 6b is a cross-sectional view taken along the line B - B of FIG. 4. FIG. 6c is a cross-sectional view taken along the line C - C of FIG. 4.

As mentioned above, the electromagnetic switch device according to the present invention has a configuration in which the timer 170 is contained in the

body 110 while being assembled to the body 110. Also, the electromagnetic switch device is configured to switch on and off the main power source by electronic switching operations conducted by an electromagnetic 130 for a main circuit and a vertical moving member 152 for the main circuit. The electromagnetic switch device is also configured to selectively enable a star connection or a delta connection in accordance with the switching operation of a single star-delta switch including an electromagnet 140 for the star-delta connection and a vertical moving member 162 for the star-delta connection. Thus, the electromagnetic switch device according to the present invention has a configuration made by composing, in the form of a single product, an electromagnetic switch device C1 for a main circuit, an electromagnetic switch device C2 for a star connection, and an electromagnetic switch device C3 for a delta connection, which have conventional configurations, respectively.

As apparent from FIGS. 8a and 8b illustrating the practical connection state of a three-phase motor, the electromagnetic switch device C, which has the form of a single product capable of achieving respective switching functions for the main circuit, star connection and delta connection, can simplify the wiring required for desired connections, as compared to the conventional case of FIGS. 3a and 3b. Moreover, the electromagnetic switch device C of the present invention exhibits superior assemblability, productivity, and stability, taking into consideration the fact that it is designed to stably achieve respective functions corresponding to those of three electromagnetic switch devices C1, C2, and C3 in the conventional case, using a single product.

FIG. 8a is a view illustrating the practical connection state of a three-phase motor to which the

electromagnetic switch device C of the present invention is applied. FIG. 8b is an equivalent circuit diagram illustrating the electromagnetic switch device C of the present invention shown in FIG. 8a.

In accordance with a preferred embodiment of the present invention illustrated in FIGS. 4 and 5, the electromagnetic switch device C includes a body 110, and first through third power terminals 121a, 121b, and 121c arranged at one side portion of the body 110 on the upper surface of the body 110 and respectively connected to three-phase power lines R, S, and T. The power terminals 121a, 121b, and 121c are insulated from one another. The electromagnetic switch device C also includes first through third main terminals 122a, 122b, and 122c arranged at an intermediate portion of the body 110 on the upper surface of the body 110 and respectively connected to one-side terminals u, v, and w of a three-phase electric motor M. The main terminals 122a, 122b, and 122c are insulated from one another. First through third star-delta terminals 123a, 123b, and 123c are arranged at the other side portion of the body 110 on the upper surface of the body 110. The star-delta terminals 123a, 123b, and 123c are connected to the other-side terminals Z, X, and Y of the three-phase electric motor M, respectively. The star-delta terminals 123a, 123b, and 123c are insulated from one another.

The electromagnetic switch device C further includes a star connection plate 124 arranged at the upper surface of the body 110 and adapted to connect the first through third star-delta terminals 123a, 123b, and 123c to a star circuit. First through third contacts 125a, 125b, and 125c are set beneath the star connection plate 124 in order to connect the first through third star-delta terminals 123a, 123b, 123c to a delta circuit.

An electromagnet 130 for a main circuit and an electromagnet 140 for star-delta connections are disposed at a lower portion of the body 110 in such a fashion that they are laterally aligned with each other while being insulated from each other. The electromagnet 130 includes a fixed core 131 and a coil 132 whereas the electromagnet 140 includes a fixed core 141 and a coil 142. The electromagnetic switch device also includes a main circuit switching unit 150 arranged above the main circuit-end electromagnet 130 in the interior of the body 110 and adapted to switch on and off the main power source. A star-delta connection switching unit 160 is set above the star-delta connection-end electromagnet 140 in order to allow the three-phase motor M to be started up in a star connection state, and then to be driven in a delta connection state.

The main circuit switching unit 150 serves to selectively connect the first through third main terminals 122a, 122b, and 122c to respective power terminals 121a, 121b, and 121c in accordance with a magnetization of the main circuit-end electromagnet 130.

FIG. 7a is a perspective view illustrating a main circuit switching unit applied to the electromagnetic switch device of the present invention.

As shown in FIG. 7a, the main circuit switching unit 150 includes a main circuit-end moving core 151 and a main circuit-end vertical moving member 152 integrally coupled together and arranged above the main circuit-end electromagnet 130. The main circuit switching unit 150 also includes three main circuit-end moving members 154a, 154b, and 154c respectively adapted to connect the first through third power terminals 121a, 121b, and 121c to the first through third main terminals 122a, 122b, and 122c in accordance with downward movements thereof conducted along with the main circuit-end moving member

152 when the main circuit-end electromagnet 130 is magnetized.

The main circuit switching unit 150 also includes main circuit-end compression coil springs 155 arranged around the moving core 151 between the upper surface of the main circuit-end electromagnet 130 and the lower surface of the main circuit-end vertical moving member 152 in order to provide a return force for returning the vertical moving member 152 to its upper position. The main circuit-end compression coil springs 155 are arranged in pair in such a fashion that those of each pair are disposed at opposite sides of the main circuit-end electromagnet 130.

The main circuit-end compression coil springs 155 serve to always urge the main circuit-end vertical moving member 152 to move upwardly in a normal state. The main circuit-end compression coil springs 155 have an elastic coefficient lower than the magnetic force of the main circuit-end electromagnet 130 in order to allow the main circuit-end vertical moving member 152 to move downwardly against the urging force of the main circuit-end compression coil springs 155 when the main circuit-end electromagnet 130 is magnetized, thereby causing the first through third power terminals 121a, 121b, and 121c to the first through third main terminals 122a, 122b, and 122c, respectively.

Preferably, the main circuit switching unit 150 further includes main circuit-end damping springs 156 for damping impact generated when the first through third main circuit-end moving members 154a, 154b, 154c abruptly contact associated fixed contacts as the main circuit-end vertical moving member 152 moves downwardly by virtue of the magnetic force of the main circuit-end electromagnet 130, respectively. Three main circuit-end damping springs 156 are provided as one set.

Since the magnetic force of the magnetized main circuit-end electromagnet 130 is higher than the elastic coefficient of the main circuit-end compression coil springs 155, the main circuit-end vertical moving member 152 may be abruptly lowered when the main circuit-end electromagnet 130 is magnetized, thereby generating impact or noise. To this end, the main circuit-end damping springs 156 are provided in order to damp impact or noise possibly generated when the first through third main circuit-end moving members 154a, 154b, and 154c connect the first through third power terminals 121a, 121b, and 121c with the first through third main terminals 122a, 122b, and 122c.

The star-delta connection switching unit 160 serves to switch the three-phase motor M between the star connection and the delta connection as it moves vertically in accordance with a magnetization of the star-delta connection-end electromagnet 140.

In detail, the star-delta connection switching unit 160 connects the star connection plate 124 to associated fixed contacts in accordance with the magnetization of the main circuit-end electromagnet 130 under the condition in which the first through third power terminals 121a, 121b, and 121c are connected to the first through third main terminals 122a, 122b, and 122c, thereby allowing the three-phase motor M to be start up in a star connection state. When the star-delta connection-end eltion-end electromagnet subsequently magnetized in accordance with an operation of the timer 170, the star-delta connection switching unit 160 connects the first through third delta connection contacts 125a, 125b, and 125c to the first through third star-delta terminals 123a, 123b, and 123c, thereby causing the three-phase motor M to be driven in a delta connection state.

FIG. 7b is a perspective view illustrating the star-delta connection switching unit applied to the electromagnetic switch device according to the present invention.

In accordance with a preferred embodiment of the present invention illustrated in FIG. 7b, the star-delta connection switching unit 160 includes a star-delta connection-end moving core 161 and a star-delta connection-end vertical moving member 162 integrally coupled together and arranged above the star-delta connection-end electromagnet 140. The moving core 161 and vertical moving member 162 are adapted to be moved together in accordance with a magnetization of the electromagnet 140. The star-delta connection switching unit 160 also includes first through third star connection-end moving members 167a, 167b, and 167c adapted to move upwardly along with the star-delta connection-end vertical moving member 162 in accordance with a magnetization of the main circuit-end electromagnet 130 under the condition in which the first through third main terminals 122a, 122b, and 122c are connected to the first through third power thermals 121a, 121b, and 121c, so that they are connected to the first through third star-delta terminals 123a, 123b, and 123c while being connected toto theconnection plate 124, thereby allowing the three-phase motor M to be started up in a star connection state. The star-delta connection switching unit 160 further includes first through third delta connection-end moving members 164a, 164b, and 164c adapted to move downwardly along with the star-delta connection-end vertical moving member 162 when the star-delta connection-end electromagnet 140 is magnetized after the time set by the timer 170 elapses, so that they are connected to the first through third star-delta terminals 123a, 123b, and 123c while being

connected to the first through third delta connection contacts 125a, 125b, and 125c, thereby causing the three-phase motor M to be driven in a delta connection state.

The star-delta connection switching unit 160 also includes star-delta connection-end compression coil springs 165 arranged around the moving core 161 between the upper surface of the star-delta connection-end electromagnet 140 and the lower surface of the star-delta connection-end vertical moving member 162 in order to provide a return force for returning the vertical moving member 162 to its upper position. The star-delta connection-end compression coil springs 165 are arranged in pair in such a fashion that those of each pair are disposed at opposite sides of the star-delta connection-end electromagnet 140.

The star-delta connection-end compression coil springs 165 serve to always urge the star-delta connection-end vertical moving member 162 to move upwardly in a normal state. The star-delta connection-end compression coil springs 165 have an elastic elastic lower than the magnetic force of the star-delta connection-end electromagnet 140 in order to allow the star-delta connection-end vertical moving member 162 to move downwardly against the urging force of the star-delta connection-end compression coil springs 165 when the star-delta connection-end electromagnet 140 is magnetized, thereby causing the three-phase motor M to be driven in a delta connection state.

Preferably, the main circuit switching unit 150 further includes star-delta connection-end damping springs 166 for damping impact generated when the first through third star connection-end moving members 167a, 167b, and 167c abruptly contact associated contact portions as the star-delta connection-end vertical

moving member 162 moves upwardly by virtue of the urging force of the star-delta connection-end compression coil springs 165 while damping impact generated when the first through third star connection-end moving members 167a, 167b, 167c abruptly contact associated fixed contacts as the star-delta connection-end vertical moving member 162 moves upwardly by virtue of the magnetic force of the star-delta connection-end electromagnet 140, respectively. The star-delta connection-end damping springs 166 are arranged in the form of a plurality of sets each including three star-delta connection-end damping springs.

Since the magnetic force of the magnetized star-delta connection-end electromagnet 140 is higher than the elastic coefficient of the star-delta connection-end compression coil springs 165, the star-delta connection-end vertical moving member 162 may be abruptly lowered when the star-delta connection-end electromagnet 140 is magnetized, thgnetized, thereby ge m . pact or noise. To this end, the star-delta connection-end damping springs 166 are provided in order to damp impact or noise possibly generated when the first through third delta connection-end moving members 164a, 164b, and 164c connect the first through third delta connection contacts 125a, 125b, and 125c with the first through third star-delta terminals 123a, 123b, and 123c. Also, the star-delta connection-end damping springs 166 serve to damp impact or noise generated when the first through third star connection-end moving members 167a, 167b, and 167c connect the star connection plate 124 to the first through third star-delta terminals 123a, 123b, and 123c as the star-delta connection-end vertical moving member 162 moves abruptly in an upward direction by virtue of the urging force of the star-delta connection-end compression coil springs 165 in accordance with a

release of the magnetic force from the star-delta connection-end electromagnet 140.

The electromagnetic switch device C of the present invention is also internally provided with an anti-arc zinc-plated steel plate (not shown) adapted to inhibit generation of an arc during the switching operation of the main circuit switching unit 150 or star-delta connection switching unit 160.

In the drawings, the reference numeral 191 denotes terminals to which power lines are coupled in order to supply current to the coils 132 and 142. The reference numeral 192 denotes bolts respectively coupled to the terminals 191 in order to provide an easy connection of the power lines to the terminals 191.

The electromagnetic switch device C for star-delta connections having having the entioned configuration operates in a selected connection state, as shown in the equivalent circuit diagram of FIG. 5, in such a fashion that it establishes a star connection, when it is desired to start up the electric motor M, in order to achieve a start-up of the electric motor M using starting current and starting torque reduced to a 1/3 level while switching the connection of the electric motor M to a delta connection after completion of the start-up of the electric motor M. For the best understanding of the present invention, elements of FIG. 5 respectively corresponding to those in FIG. 4 are denoted by the same reference numerals.

Now, the operation of the electromagnetic switch device C for star-delta connections according to the present invention will be described.

When current flows through the coil 132 of the main circuit-end electromagnet 130, which is constructed by the fixed core 131 and the coil 132, upon starting the three-phase electric motor M, the electromagnet 130

is magnetized by virtue of the current. Simultaneously with the magnetization of the electromagnet 130, the timer 170 begins to count the activation time of the electromagnet 130.

As the electromagnet 130 is activated, it generates a magnetic force greater than the urging force of the main circuit-end compression coil springs 155, so that the main circuit-end moving core 151 and main circuit-end vertical moving member 152 are downwardly moved. At the same time, the main circuit-end moving members 154a, 154b, and 154c are downwardly moved, thereby causing the first through third power terminals 121a, 121b, and 121c to be connected with the first through third main terminals 122a, 122b, and 122c, respectively.

In such an initial state, the star-delta connection-end electromagnet 140 is maintained under a non-magnetization condition, that is, a condition in which no current flows through the coil 142. Accordingly, the star-delta connection-end moving coil 161 and star-delta connection-end vertical moving member 162 are maintained in a state in which they are spaced away from the coil 142 by virtue of the resilience of the star-delta compression coil spring 165. In this state, the first through third star connection-end moving members 167a, 167b, and 167c, which move upwardly along with the star-delta connection-end vertical moving member 162, connect the star connection plate 124 to the first through third star-delta terminals 123a, 123b, and 123c the star connection-end moving contacts 167a, 167b, and 167c, thereby allowing the three-phase motor M to be start up in a star connection state.

Thus, the three-phase electric motor M can be stably started up in the initial state by electric power supplied via the three-phase power lines R, S, and T

respectively connected to the power terminal 121a, 121b, and 121c.

After a predetermined period of time elapses, current flows through the coil 142 of the star-delta connection-end electromagnet 140 in accordance with an operation of the timer 170. By virtue of the current, the star-delta connection-end electromagnet 140 is magnetized.

As the electromagnet 130 is activated, it generates a magnetic force greater than the resilience of the star-delta connection-end compression coil springs 165, so that the star-delta connection-end moving core 161 and star-delta connection-end vertical moving member 162 are downwardly moved.

At the same time, the first through third star connection-end moving members 167a, 167b, and 167c are downwardly moved, so that they are separated from the star connection plate 124, thereby releasing the star connection state. Also, the delta connection-end moving members 164a, 164b, and 164c come into contact with the first through third delta connection-end contacts 125a, 125b, and 125c and the first through third star-delta terminals 123a, 123b, and 123c, thereby causing the three-phase motor M to be started up in a delta connection state.

Thus, the three-phase motor M initially has a star connection state, so that it is stably started up by electric power supplied via the three-phase power lines R, S, and T respectively connected to the power terminal 121a, 121b, and 121c. Following the start-up, the star-delta connection-end electromagnet 140 is magnetized, so that the first through third delta connection-end moving members 164a, 164b, and 164c connect the first through third delta connection-end contacts 125a, 125b, 125c with the first through third star-delta terminals 123a,

123b, and 123c, respectively, thereby allowing the three-phase motor M to be driven at a full speed.

Industrial Applicability

As apparent from the above description, the electromagnetic switch device according to the present invention has a configuration in which the timer 170 is contained in the body 110 so that it is integral with the body 110. Also, the electromagnetic switch device has a configuration in which the system for switching on and off the main power source and the system for switching the connection of the three-phase motor M between the star connection and the delta connection are contained in the body 110 so that they are integral with the body 110. By virtue of such configurations, the three-phase motor M can be stably and simply driven in a three-contact fashion.

That is, in the electromagnetic switch device according to the present invention, the timer 170 is contained in the body 110 while being integral with the body 110. Also, the electromagnetic switch device is configured to switch on and off the main power source by electronic switching operations conducted by the main circuit-end electromagnetic 130 and the main circuit-end vertical moving member 152. The electromagnetic switch device is also configured to selectively enable a star connection or a delta connection in accordance with the switching operation of the star-delta connection-end electromagnet 140 and the star-delta connection-end vertical moving member 162. Thus, it is possible to simplify the wiring required for desired connections, as compared to the conventional case. Moreover, it is possible to achieve improvements in assemblability and productivity while preventing erroneous connections, thereby obtaining an enhanced stability.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.